From ancient times to later periods a mass of bitter and nauseous substances were found and stored in the medical armory, used in the battle against disease. Now the time was ripe for the pharmaceutical chemist who devoted his energies to the problem of active principles (such as alkaloids, glucosides, resins, etc.) from these simple bitter substances, thus finding out their chemical composition and the relation these had as antagonists to disease. We have then, as a result, the principles well known as quinine, morphine, atropine, aconitine, strychnine, digitalline, cocaine, codein and a host of others, and these have been (with coöperative work with physicians) *classified* with reference to their disease antagonistic properties. So that now we are entering upon the domain of *rational* therapeutics, and pharmaceutical chemistry has come to its own as a distinct science, while medical practice has all it can do to attend to its specialized field, which, like pharmacy, is rapidly becoming divided into groups of specialists that promises for the future greater and greater efficiency.

University of Kansas, Lawrence.

The Progress of Science Since the Foundation of the Kansas Academy of Science.

SAMUEL W. WILLISTON.

It was fifty years ago last autumn that, as a lad, I came under the instruction of the late Prof. B. F. Mudge of the Kansas Agricultural College. Bred as a lawyer in Linn, Mass., his early love for science led him into the study of chemistry, mineralogy and geology. Serving for a while as chemist in an oil refinery in Kentucky, his staunch New England training sent him, like so many others in those days, to Kansas, the border land of freedom, where, after a brief service as state geologist, he was made professor in the new Agricultural College.

It was his lectures on geology in Manhattan that inspired in me, a boy—inspired is the right word—the love for science that has lasted throughout my life. For ten years I was more or less under his guidance and influence, in the school room and in the field. My debt to him has never been, can never be repaid. He taught me all of science that was then taught in highest institution of learning in Kansas—natural philosophy as it was then called, chemistry, geology, botany, mineralogy, zoölogy, veterinary science, surveying and mathematics; and for a while even he was my instructor in Latin. A beloved teacher, a noble and upright man, he loved science for science's sake, without regard for personal emolument. He was the real founder of this Academy; nay more, the founder of science in the young state of Kansas, and as such his name will never be forgotten in its annals.

I recall vividly the beginnings of this Academy and the part that he took in its foundation. I wonder if there are others who do? And I recall the talk he gave his pupils about it and what he hoped for its future. I would that I could tell him how grandly his hopes have been fulfilled. The Academy has had an honorable past; may its future still be as bright as he foresaw.

It is then fitting in this, our celebration of the completion of the first half century of its history, that we render tribute to this good man. And he was a good man. And in his modest way he was a great man; his name shall be remembered as long as this Academy lasts; yea, as long as Kansas lasts. It was not until ten years later that I became a member of it, proposed for membership, I am proud to say, by Professor Mudge, and read my first paper before it, almost my first attempt in science authorship. I remember some of its members of those early days, my preceptor in medicine, Dr. J. Robinson, among them. There are others who remember more. Among the founders was another dear friend, my colleague at the University of Kansas for twelve years, Prof. Frank H. Snow. His name, too, like that of Mudge, is engraved in *aes perennis*.

To most of my hearers fifty years is a long time. To me in my memory of those events and of those faces it is as but yesterday. None of its founders now remain and few of its earliest members.

But in science the time has been immeasurably long, long in its accomplishments, longer than all the thousands of years of civilized history prior thereto. I can recall vividly my youthful summary a few years later of the accomplishments of science in the preceding fifty years. They seemed vast to me then in my youthful wonder. The chief things were the electric telegraph, photography, the locomotive, and the conservation and correlation of forces, to which I may now add organic evolution. And great indeed they were, fraught with the germs of our achievements of the past fifty years. One sentence of my college essay lingers in my memory: "Science has made a greater advancement in the past fifty years than in all the preceding centuries!"

He is a learned man to-day who is the master of a very small part of what has been accomplished in these years. Professor Mudge taught me the elements of all the natural and mathematical sciences of those days; at least twenty college teachers of the same to-day would find their subjects wide. There are scores of sciences to-day that have libraries larger than that of all science in those times. There were then perhaps a score of men in the United States who were actively engaged in scientific research, men whose names were known throughout the nation among the scholarly, and perhaps a hundred or two throughout the world; there are thousands to-day, and there will be tens of thousands to-morrow. The profession of science was then precarious, and its emoluments uncertain. The scientific investigator was rarely wanted as a teacher, he was thought to be unpractical and theoretical, for the world at large still looked upon most science as merely bundles of useless theories. College teachers in science as in other branches were usually chosen from among professional teachers or the clerical profession. Medicine was almost the only available avenue to pure science and that was the chief reason why I studied medicine. Perhaps the first chemical laboratory in the state of Kansas was organized at the Kansas Agricultural College in 1873, with Professor Kedzie in charge. The first compound microscope I ever saw was in the same year. The Agricultural College catalogue for 1868 gravely included in its list of its equipment for the teaching of science, a collection of minerals and fossils made by Professor Mudge, an electrical ma-

chine, two Leyden jars, a gas bag and six test tubes. There was but one scientific society then in the United States, and but one or two scientific periodicals; now there are so many that few pretend to know their names even.

Perhaps these few words will convey some conception of the state of science in the United States, and especially in Kansas, when this Academy was born. Do you not then reverence the courage or idealism of those few devoted founders of this Academy which they dedicated to the advancement of science in this, a frontier state?

To recount, even in the most general way, the progress of the sciences in these fifty years is almost beyond the limits of my time and opportunity, to say nothing of my ability. And the subject loomed so large to me that I would have lost courage to undertake it had I not felt conscious of the support my colleagues would give me. They told me, almost all whom I consulted, that the history of each science for the past fifty years comprised its larger part. Told me some of them almost in the words that I had used nearly fifty years before of the progress of science in the preceding fifty years. Will the same be said fifty years hence? I doubt it not.

I may say with assurance that, in nearly every branch of science, progress in these years has been from the descriptive to the analytical, from the search after facts to the search after reasons, for causes; from the *is* to the *why*. Facts are still accumulating, accumulating as never before, but it has been their interpretation and application that has been the basis for the greatly accelerated progress of this last half century. And I think that I can say without fear of contradiction that, underlying all else, were the two great discoveries of the preceding fifty years—conservation of forces and organic evolution. The discovery that heat, light, electricity and force were merely modes of motion was the most fundamental of all, even evolution, for it was in a way but its application to organic life. How like a fairy tale it read to me a few years later.

In biological science the doctrine of evolution has been the foundation of our progress. It was only a few years after the founding of this Academy that Darwin published the last of his famous works on evolution, "The Descent of Man." Previous to 1872 the world at large took only an academic interest in "Darwinism"; with its application to man himself it became of absorbing interest from the cottage to the palace. And as so often when arguments in refutation failed to convince, ridicule and obloquy took their place. It took years to establish the doctrine, but with its general acceptance among scientific men, a new epoch in biological science began, the epoch of analysis and the search for causes. You will pardon the pride I take in saying that the first public lecture in defense of evolution in the state of Kansas, so far as I am aware, was by myself in 1874 at Manhattan. It was a youthful production, with all the assurance of youth, and I suffered for it in the public estimation. Dire things were prophesied for my future. I trust that I have outlived my evil repute of those days.

Even as a boy takes his watch to pieces to see how it is made, we began a half century ago to take things apart, first, like the boy, in the

mere spirit of curiosity to see how they were made, later to find out the laws that govern their construction and to make other things. Analysis must necessarily be the antecedent of synthesis, and synthesis is constructive science. Science for centuries had been more the search for things to prove theories, the handmaid of philosophy. In these years science has been preëminently in the search for theories to explain facts, the mistress of philosophy. It has been in the search for causes and the application of causes in reconstruction. And all this has brought about the correlation of underlying causes, the correlation of the sciences. Then the chief sciences were like islands in a great expanse of water of unknown depths; now they are for the most part united into one land with only valleys at the most between them. Physics and chemistry have been called upon for the explanation of geological and biological phenomena. Physiology and pathology have become merely the physics and chemistry of life; paleontology the history of geology, and so on to the end. And, ever and anon we gaze in amazement at the new fields opening before us in the application of one science to the explanation of another science.

In the science of the universe the application of the spectroscope, discovered only a little earlier, to the determination of the constitution of the sun and stars, has been marvelous in its results; and it has found many new uses. And the application of photography, which antedates our Academy's history not many years, has all been made during these years with equally marvelous results. The larger part of our present knowledge of the sidereal universe has been acquired since 1868. The modern telescope is twenty-five times more powerful than the telescope of the sixties; our vision has been enlarged a million times. The determination of the earth's interior, as rigid and elastic as though composed of steel, has been a discovery of recent years, a discovery which bids fair to revolutionize all our conceptions of the dynamics of the earth.

In geology a better conception of the origin and structure of the earth marks a new epoch in its history. The earth has not been growing colder from a primitive ball of fire; its molten interior no longer exists, and vulcanology has become a new science. An earth of elastic rigidity explains better the base leveling of the continents and the periodic oscillations of the oceans, and indeed all of the great earth movements of the past, and the intimate part they play in its history.

When this Academy was founded I was taught that the boulders scattered over our hills had been dropped there from mighty icebergs in a universal ocean of our continent. But there came a new science of glaciology, and a history of their past in Paleocene, Permian, Cambrian and Proteozoic times. And all these new conceptions of the earth have thrown a flood of light upon the climates and life of the past. And the science of physiography has been born in these years.

When Mudge was the state geologist of Kansas he was thought to be a wizard to unlock all the hidden treasures of the earth. If gold and silver were to be found in Colorado, why not in Kansas? Coal was sought for on the highest bluffs and precious metals and stones in the

limestones, to be found if one dug enough for them. Economic geology has taught us where to look for such things and where the search is vain. A better interpretation of ore deposits, and the relations of ore formation to igneous rocks has enriched the world's resources and saved many, many millions of dollars in wasted efforts. And Kansas certainly knows that the formulation of structural theories of the occurrence of oil and gas reservoirs has added immensely to the wealth of state and nation.

The science of chemistry, too, has been reborn in the years, and its application to man's economic needs is greater perhaps in amount than in any other science. In the days when this Academy was very young was established the law that properties of elements are periodic functions of their atomic weights, as a foundation for the new chemistry. The science of carbon compounds, of organic compounds, has progressed marvelously, and with it the whole science of dye compounds and the synthesis of drugs, based upon the discovery of the space relations of atoms and the reconstruction of our conceptions as to the structure of matter. The theory of ionization and the whole science of physical chemistry are products of these years. Witness, for instance, the successful extrication of nitrogen from the air, and its immense possibilities both in war and in peace. And who knows yet what will result from the discovery of radio-activity in both physics and chemistry? Many new compounds have been discovered in these years.

In none of the sciences does the history of achievement read more like a mythological tale than in the science of physics. Had one, a century ago, predicted them he would straightway have been led to an asylum. In 1869 I well remember that Professor Mudge, in showing his pupils the sparks from a Leyden jar, predicted that before many years electricity would light our streets. And most people thought such a prediction the irresponsible vaporings of a theorist. Let one harken back to the tallow dips of the fifties, the camphene and crude kerosene lamps of the sixties, and compare them with the lights of to-day. How far indeed from the spark of Franklin's kite!

Maxwell, when this Academy was very young, foreshadowed the wireless telegraph in his magnetic theory of light, verified by Herz in the electromagnetic waves, and applied by Marconi to that greatest wonder of all science, the wireless telegraph. Telephony and phonography, discoveries of the early seventies, are now such common and necessary adjuncts of civilization that one wonders how crude things were when they were unknown. And last, but far from least, Darius Green and his flying machine as an established fact may be the final decision in the world's greatest, and we confidently hope victorious war against barbarism. It was a physicist, Langley, who invented it, and physics taught him how. And I have not forgotten the discovery of X-rays and what it means in physics and chemistry.

Stop for a moment and consider what these discoveries and their application in physics mean to us to-day; to converse in living tones through thousands of miles; to imprison our voice to be released at will perhaps a thousand years hence—think what it would mean could the

Sermon on the Mount be heard in the living voice of Christ to-day; to send human messages about the earth through the air with the speed of light; to look through what seemed opaque things; and to fly through the air with the speed and freedom of birds. They almost seem, even yet, to those of us who remember the time when they were not, like the dreams of a disordered mind.

In the biological sciences the records of progress in these years are no less startling. How commonplace have many of these new things become to us in our familiarity with them; how greatly have they modified and are modifying the conditions of human existence.

On the borderland between botany and zoölogy, among those curious organisms that Haeckel once called the Protista, the discoveries of the parts microörganisms play in our happiness and our welfare are most profound. Bacteria, long mere curiosities to the curious, we have recognized as our greatest enemies and our greatest friends among living things, perhaps the greatest of all factors in the development of our race. The germ theory of the early eighties was received, I can well remember, with incredulity; its application to human needs has saved myriads of lives, untold tortures and untold anguish. The mother blesses the day when Pasteur recognized their instrumentality in disease, that saves the babe in her arms. The soldier on the battle field is saved from greater foes than the enemies' guns by that same discovery.

And microzoa, curious creatures they were when this Academy was born; deadly enemies that slay their millions we now know them to be. Mosquitoes, tzetze flies, lice, ticks, rats, then were only annoying vermin; we have recognized them now as hosts of our deadliest enemies. To conquer our enemies we must first know them; we are learning to know them in these years, and whether in the laboratory or on the battle field we shall conquer them. Cholera, typhoid fever, diphtheria, malaria, yellow fever, typhus, sleeping sickness, bubonic plague, have been unmasked. We are driving them from their trenches, and some day we shall conquer the enemy in the great white plague and he shall be no more upon earth. Never again will cholera or black death reap their deadly harvests of the past. Anæsthesia was young when our record begins; it has saved untold suffering in these fifty years. But aseptic and antiseptic surgery was a greater boon, for it has saved untold lives. These discoveries are perhaps not as spectacular as some we have recounted, but who could wish to live in those dark ages of medical science when we knew them not?

Botany is no longer merely the collection and labeling of plants, the science I studied when a boy. It is now a group of sciences, each far greater in extent than the whole subject of those days, aside from bacteriology a science now primarily of plant functions, habits, heredity —physiology, ecology and genetics. To a botanist is due the discovery of the far-reaching law of inheritance, Mendel's law. And De Vries, whatever may be the significance of his discoveries of mutation, placed the whole science on an experimental basis. The study of the vascular anatomy of plants and its service in plant genealogy has transformed

the science; and, like zoölogy, it is no longer the mere tool of geology, but paleobotany, or plant paleontology, has risen to a dignity of its own.

The application of botany to human uses is revolutionizing agriculture, and changing the whole field from an art to a science. Indeed the whole science, to quote Professor Coulter, like so many others, has been made anew in these fifty years.

And what has been said of botany applies with yet greater force to the old science of zoölogy. Then, like botany, it was chiefly a descriptive science, the description and classification of animal life, and as such I studied it fifty years ago. Now it is a large group of sciences dealing with the phenomena of animal life. Its growth even within my own memory has been marvelous. In my youth it was chiefly the study of taxonomy; then the more intimate study of gross structure, comparative anatomy; then of microscopic anatomy, histology; next of the structure and function of the cell, leading naturally into the study of the germ cell, cytology; next the study of habits and environments, ecology; lastly of heredity, or genetics. And each of these was practically a new science, with its own votaries, its own laboratories, its own libraries. More than in any other science evolution was the stimulus of its growth. The search for the factors of evolution led to the theories of Weissman, which, however well they have stood the test of time in their details, served as the inspiring stimulus to experimental zoölogy, which has been the dominant field of advancement in recent years. Mendel's discovery and its rediscovery has been extended from botany to all biological science. And, the more intimate correlation of zoölogy, chemistry and physics has made a new science of physiology.

As in botany, the practical application of the new sciences of animal life to the field of agriculture has given a profound impulse to stock breeding, changing it from an art to a science. And in the fisheries, too, the zoölogical sciences are making great changes.

The science of human anatomy is an old one. As a descriptive science it approached perfection long ago more nearly than any other, because it has to do so immediately with man. As a branch of the great science of animals, zoölogy, it acquired first of all a dignity of its own, and its progress has been along similar lines and in like fields. Advances have been made in the study of the human embryo, of the nerves on the basis of the functional neurone system, in the structure of the cell, and of the protoplasm. Not the least has been the vital culture in vitro of human tissues, with its wide possibilities along new fields of investigations and their immediate application to man's welfare.

The science of paleontology, the history of animal life upon the earth, has ceased to be merely the handmaid of geology. The paleontologist is no longer the mere gatherer of curious petrifactions in the rocks to help the geologist name his rocks. Those lifeless fossils of a half century ago have become alive again, and their teachings have thrown a brilliant illumination upon the origin, relationships, taxonomy and genealogies of organisms. On the border between geology and biology it has united the sciences so that there is no longer even a valley between them. Fossils have explained many things that seemed inexplicable in the structure of

organisms, have solved many geologic problems, and have furnished a rational basis for the science of paleogeography. And above all, it has furnished the best proofs of organic evolution.

It is still largely in the descriptive stage, the morphological stage, because it was the last of the biological sciences to seek for facts. But to the vastly increased accumulation of facts in these years it has applied analysis. Fifty years ago we knew almost nothing of the past vertebrate life of our continent north or south, and comparatively little of other parts of the world. But the rocks have yielded up their secrets to many more searchers in these past fifty years. There can be no classification of animal or plant life without paleontology. There can be no intelligent history of the earth without paleontology. There can be no real knowledge of the structure of organisms without paleontology; no real proofs of evolution without paleontology. And paleontology is doing all these things.

The science of psychology, too, is a product of these fifty years. The little that I learned of it when a youth was embraced in what was called "Mental and Moral Philosophy"; its relation to biology was then very slight, a descriptive science, if science it could be called, like so many others. Its great development in these years has been due chiefly to its intimate correlation with anatomy and physiology and experimental study. There are now hundreds of experimental laboratories where there were none in those days. Mind has been studied as a function of the brain and nervous system in health and disease; the study of abnormal psychology with an immense enlargement of our knowledge of insanity, hynosis, or mesmerism as we called it then, multiple personality and all forms of hysteria. It has taught us vastly about the mysterious thing we used to call instinct in the animals below us, and furnished us an immense increase in our knowledge of their mentality. And finally the application of this knowledge to human needs has been of great aid to medicine, education, business and all industries.

And there are many other sciences which time forbids me even to mention, which have had their birth or been greatly extended in these years. I can say nothing of the mathematical sciences and their applications that have contributed much to advancement in all science. In whichever direction we turn we see the applications of science to man's economies, to his happiness and welfare, yea to his very existence. In the science and art of medicine in particular, we have mentioned some of the contributions of physics, chemistry, botany, zoölogy, anatomy and psychology. In diagnosis, prophylaxis, sanitation, surgery, medicine and therapeutics the doctor of medicine of a half century ago had the feebleness of a child in comparison with his strength to-day. And also in war how terrible have been the contributions of physics and chemistry; how beneficent those of sanitation and the medical sciences. The applications of nearly all branches of science to agriculture have been no less great, no less beneficent. Compare the farmer with his hoe of fifty years ago.

But it is vain to attempt the enumeration of all the gifts science has conferred upon man in these fifty years of the Academy's existence. It is almost another world. The world of fifty years ago considered the

pure scientist as a harmless sort of a lunatic who found pleasure in doing all sorts of silly and foolish things of no or little account to mankind, an impractical theorist at best. And there are still those who ask what is the use? But not many now. Without him there would have been few discoveries, for discoveries and invention are not the results of accident, and man would still be in the infancy of civilization. He is coming to his own, and the harvest is ripe for his sickle.

And our own country has had an honorable part in this advancement of science and its applications. I am not boasting in saying that no other country has done more, that none other will do more in the future. May the Kansas Academy of Science celebrate its centenary as an honorable participant in the coming progress of science.